ABS Data Compressing Kickoff Meeting-
Real and Simulated PCC Study Results

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ABSTARCT

ABS will produce unprecedented volume of information rich atmospheric and environmental remote sensing data. In this part 2 presentation we are presenting the detail procedure of using PC based "ground-based" and "on-board" data compression using both real and simulated hyperspectral dataset obtained from GIFTS, AIRS and NAST-I instruments.

Outlines

- GIFTS/NAST-I/AIRS data Compression Study Results
  - DPCC Vs. Partial DPCC
  - Segmental Interferogram DPCC
  - Radiance DPCC
  - Ground Based vs. On-board
  - Hybrid DPCC
  - Noise Estimation
  - Retrieval Impacts

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Current GIFTS/NAST-I/AIRS Data Compression Study Status

- Dependent Principal Component Compression (DPCC) algorithm can be used with efficient on-board compression with limited success due to restricted on-board processing resources (GIFTS Data Compression Experiment)
- A similar DPCC algorithm applied to real NAST-I ER-2 field campaign data shows applicability of the approach with greater success since there has no processing limitation. It demonstrates that the DPCC not only can compress data efficiently but also reduce measurement noise.
- DPCC also applies to the simulated AIRS orbital data and reconfirm its compression validity. DPCC not only can represent information in a compression form but also can characterize noise in a quantitative way.

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What is PCA?

- PCA is Principal Component Analysis, a classical approach to the problem of linear (independent) feature extraction
- PCA essentially performs Singular Value Decomposition of the Covariance Matrix
- For Gaussianly distributed input, PCA extracts statistically independent features

GIFTS Data Compression Experiment (On board Only)

- **Compression (Uncalibrated Interferogram Segmental)**
  - Selection of the variable length of the segments
  - Derivation of the PCs from selected spectra of simulated data cube
  - Uncalibrated IFGs compression demonstration with limited FLOPS (for all limited aerial scene and calibration target/blackbody data)
- **Calibration**
  - Perform calibration of both original & compressed IFGs (using original and compressed black body, respectively)
- **Evaluation/Comparison**
  - Evaluation/Estimation of the noise components (total, correlated, uncorrelated) for the original spectra
  - Estimation/Evaluation of the noise components (total, correlated, uncorrelated) for the compressed spectra
  - Comparisons of data correlation noise before and after compression
  - Comparisons of compression residual with noise
  - Comparisons of Retrieval (Impact) with and without data compression

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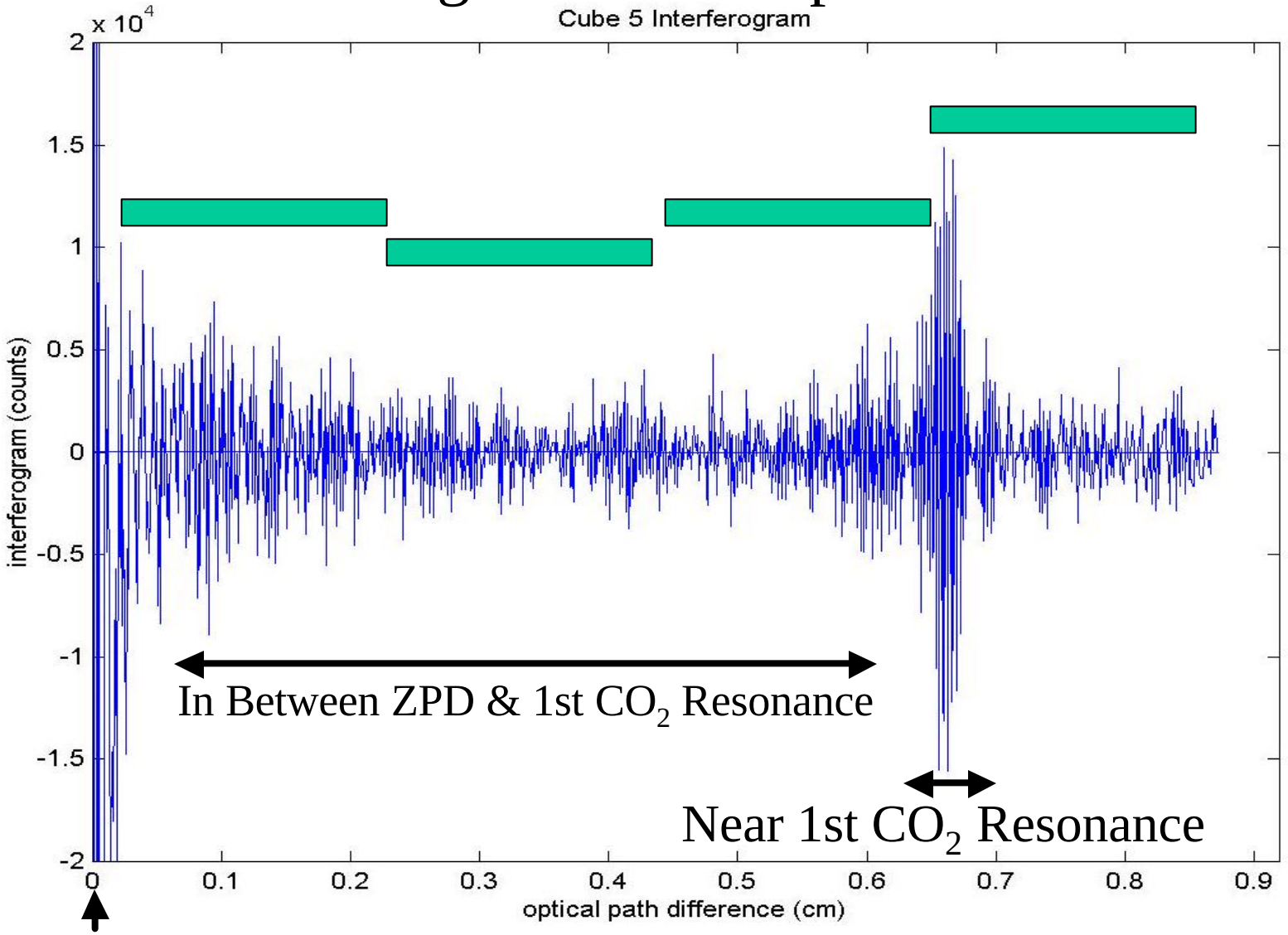
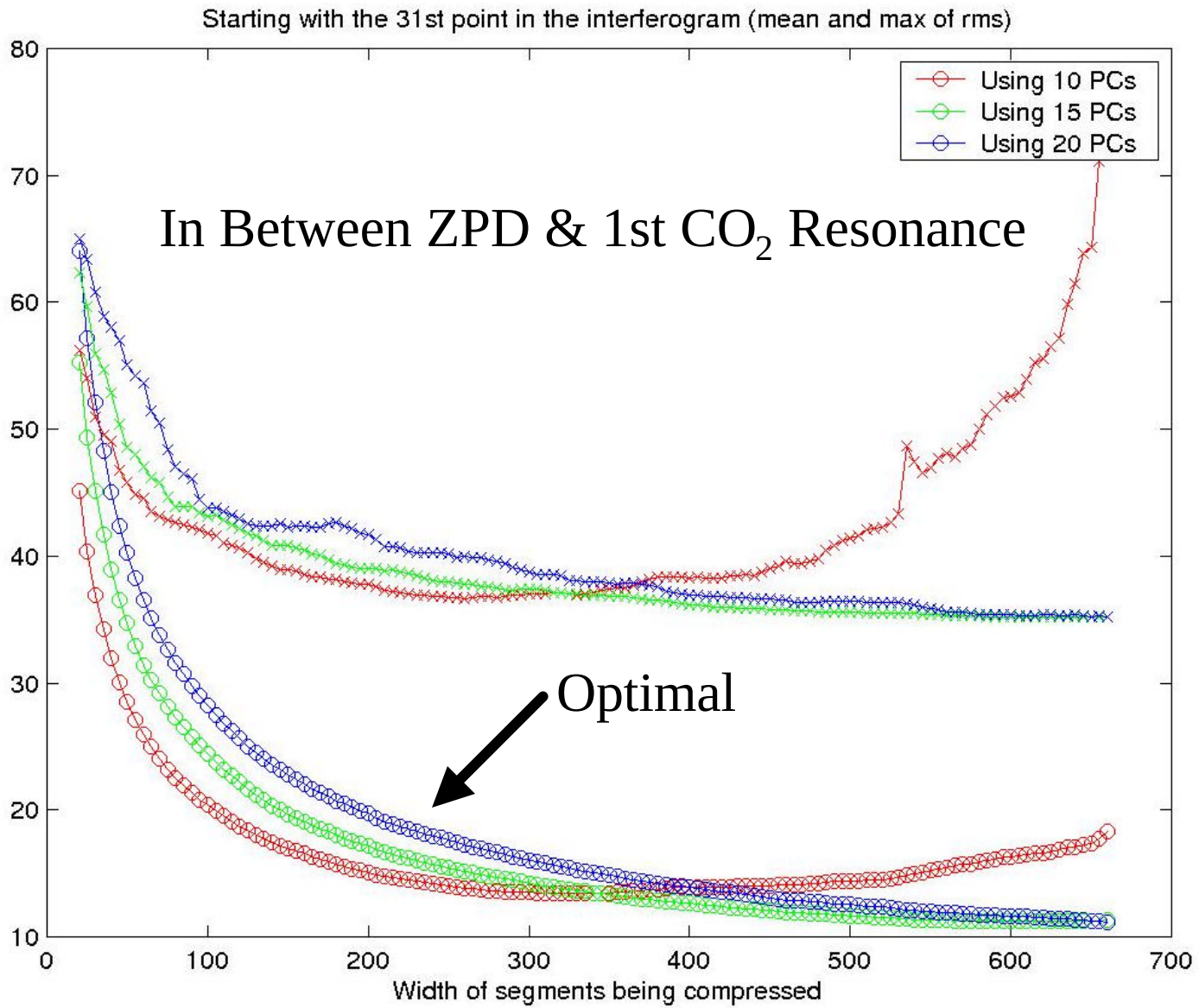
Simulated Interferogram - PC Segmented Compression

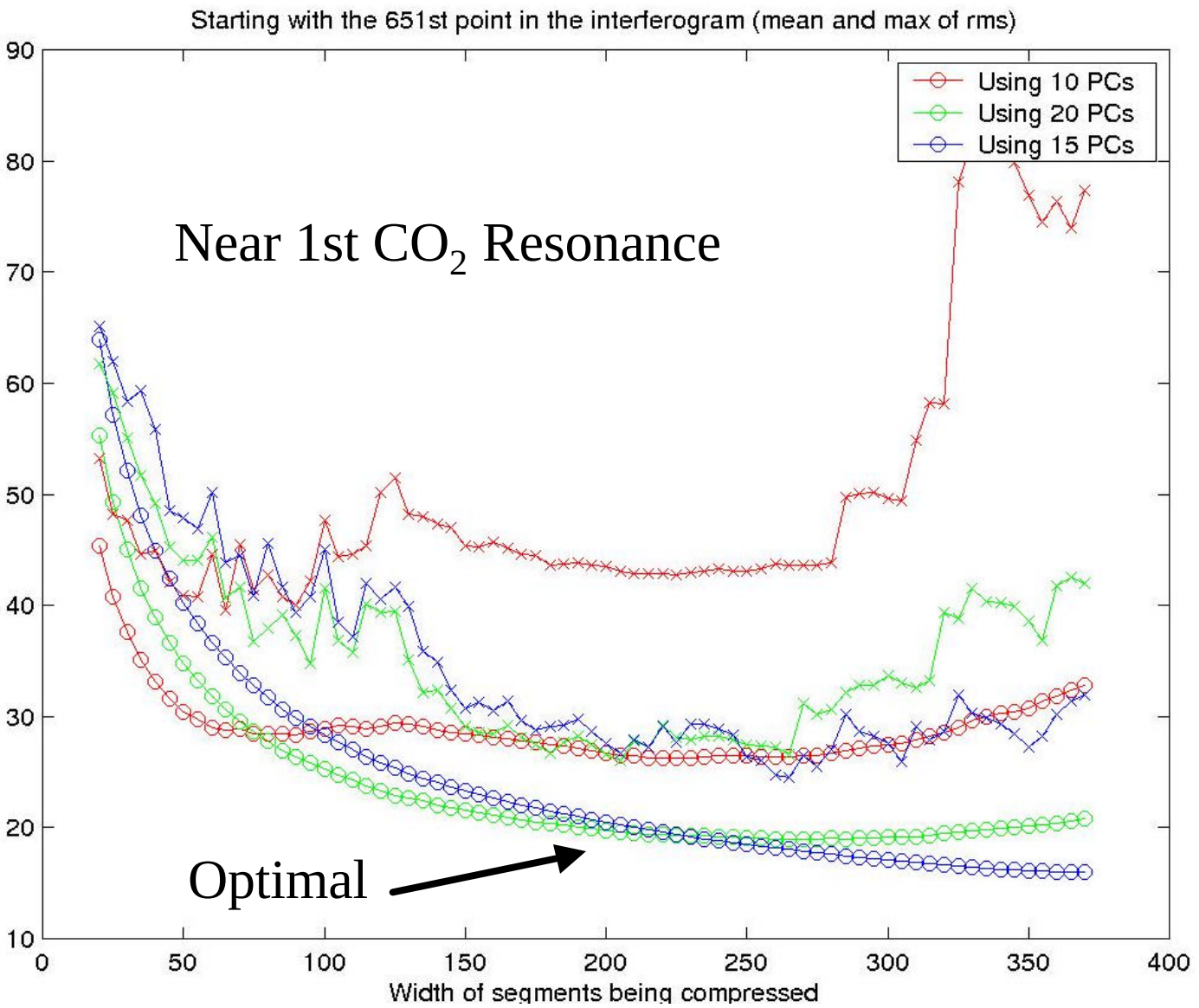


Zero Path Difference (ZPD)

Trade of PC Segment Compression



Trade of PC Segment Compression



Definitions

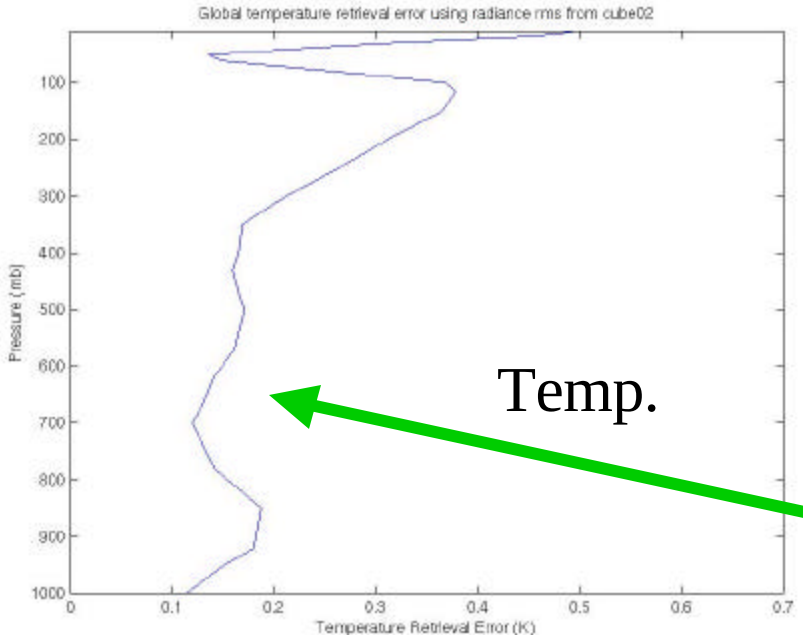
Old DPC: Old Dependent Principal Component (fixed point segments)

New DPC: New Dependent Principal Component (Variable point segments)

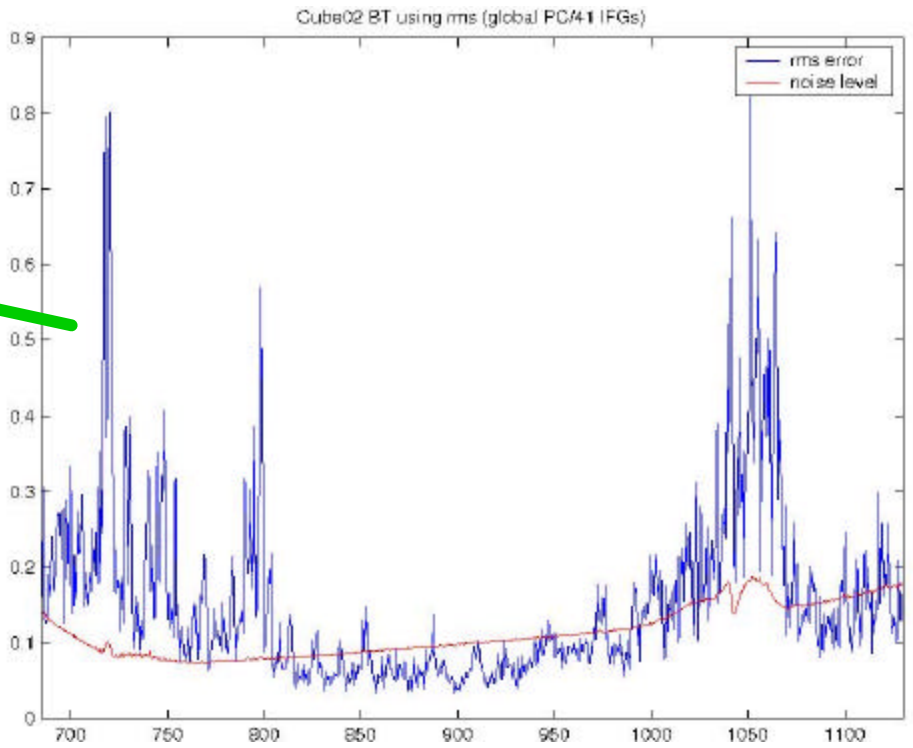
New HPC: New Hybrid Dependent & Independent Principal Component (Variable point segments and PCs are derived from on-line dependent and off-line independent historical/pre-computed data)

Note: 1. New DPC achieves better compression than old DPC
2. New HPC requires much less on-board processing than New DPC but degrades compression performance

HPC Compression Impact on Retrieval - Cube 2



Temp.



AIRS Data Compression Exercise (Ground Based Only)

- **Compression (Calibrated Spectra)**
  - Selection of domain of area (granule?) for spectral DPC derivation
  - Derivation of the PCs from all spectra of simulated data cube
- **Calibration**
  - Perform calibration of both original & compressed IFGs (using original and compressed black body, respectively)
- **Evaluation/Comparison**
  - Evaluation/Estimation of the noise components (total, correlated, uncorrelated) for the original spectra
  - Estimation/Evaluation of the noise components (total, correlated, uncorrelated) for the compressed spectra
  - Comparisons of data correlation noise before and after compression
  - Comparisons of compression residual with noise
  - Comparisons of Retrieval (Impact) with and without data compression

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Hyperspectral Data Processing -

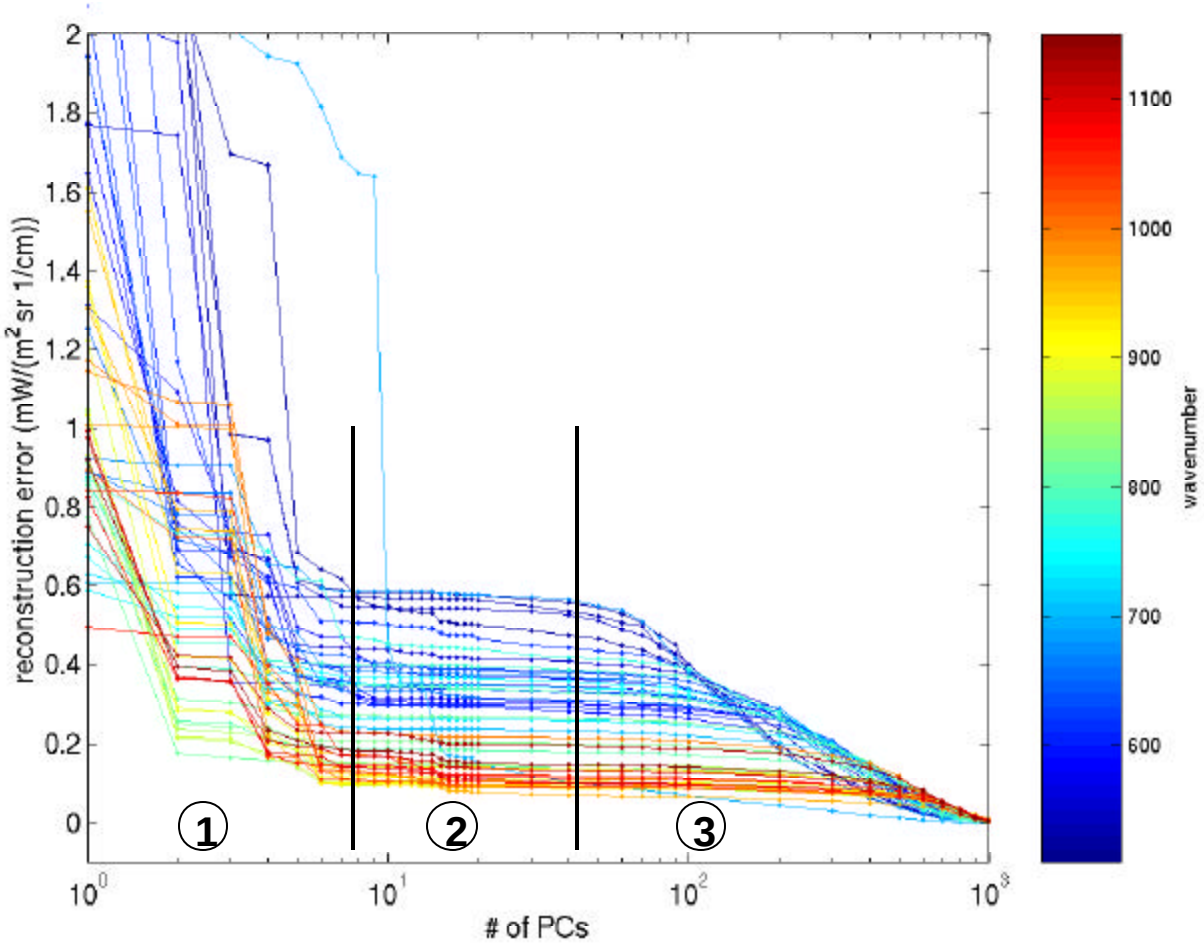
Why can we Estimate Noise Effectively ->

Signal & Noise are Estimated Separately

1 - Signal under represented

2 - Signal well represented; Noise filtered

3 - Signal & noise both duplicated



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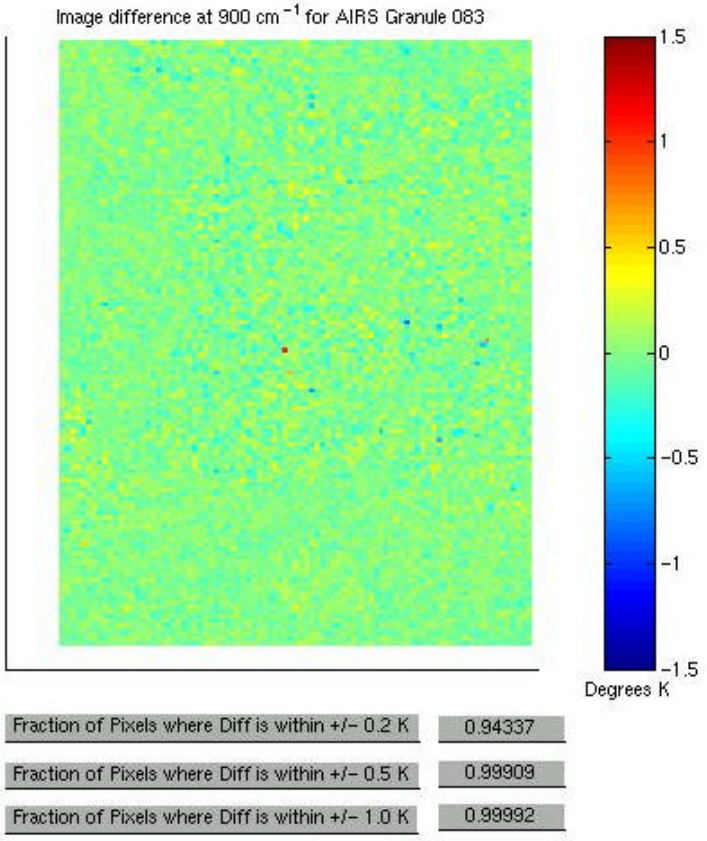
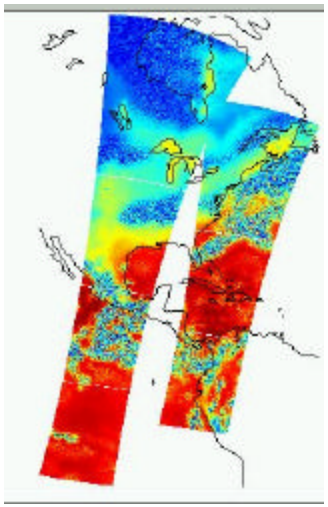
Hyperspectral Data Processing -

Why can we Compress Data Effectively ->

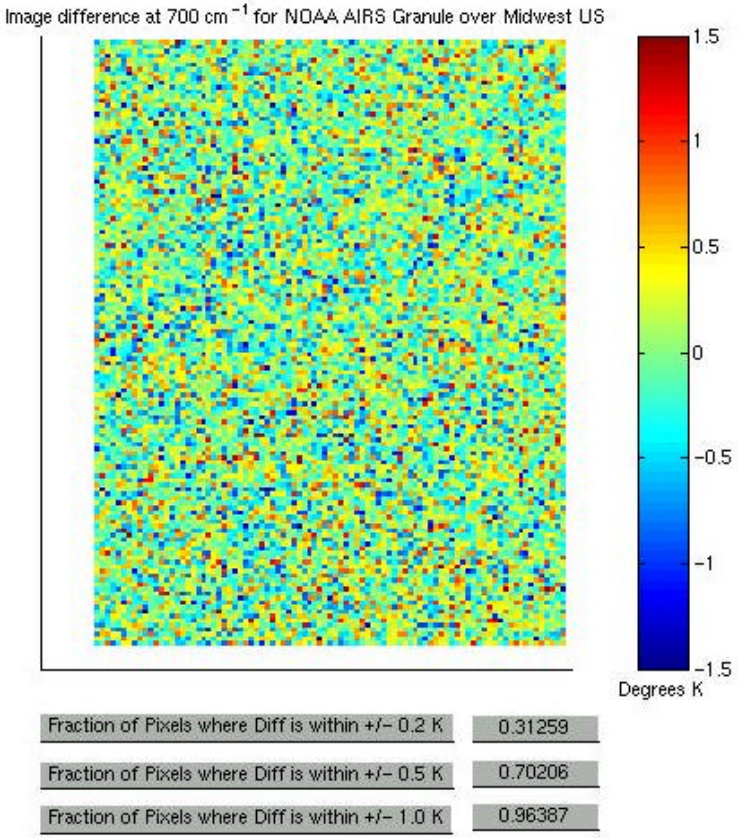
Signal Can Be Duplicated

900 1/cm





700 1/cm



99.9 % <±0.5 K

20 PCs

70.2 % <±0.5 K

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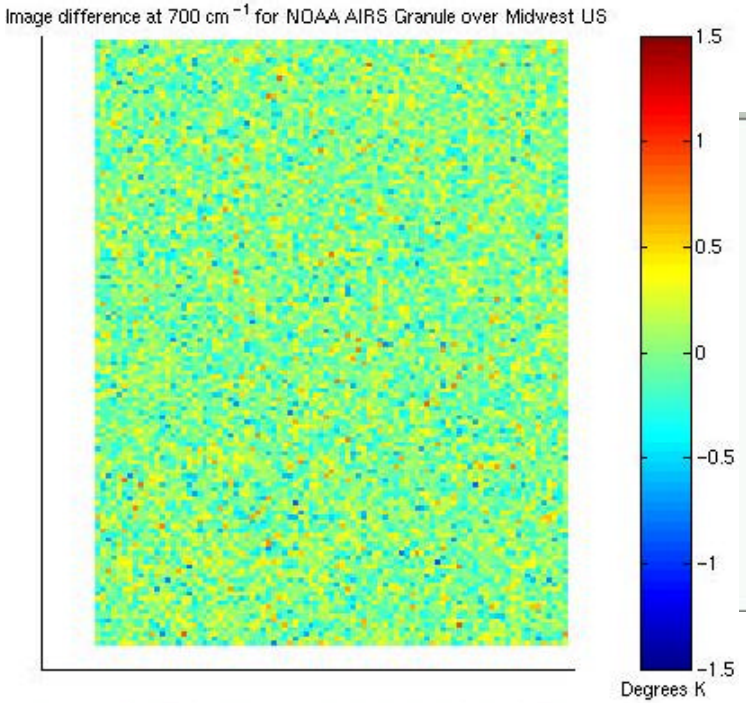
Hyperspectral Data Processing -

Why can we Compress Data Effectively ->

Signal Can Be Duplicated

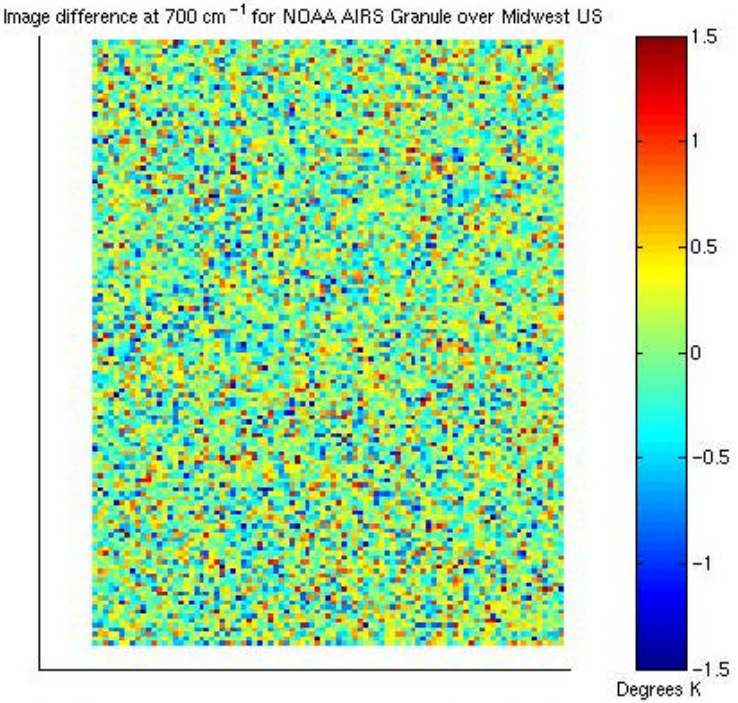
700 1/cm



99.9 % <±0.5 K

300 PCs

700 1/cm



70.2 % <±0.5 K

20 PCs

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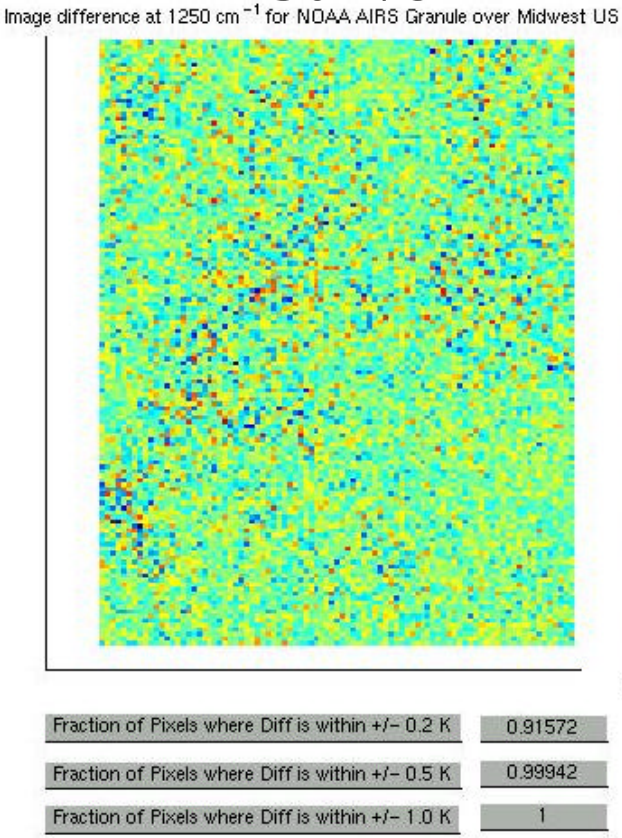
Hyperspectral Data Processing -

Why can we Compress Data Effectively ->

Signal+Noise Can Be Manipulated

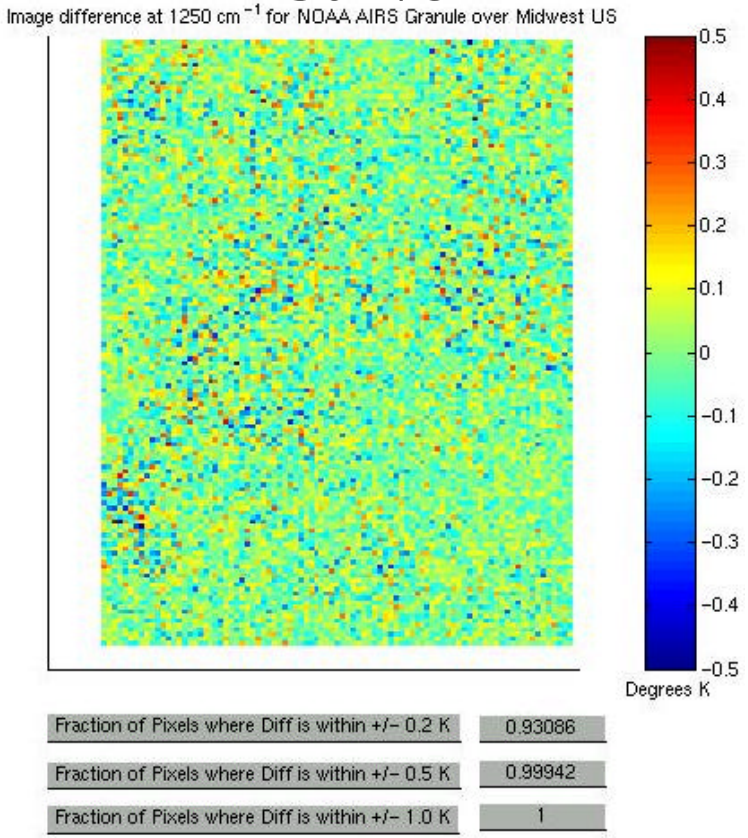
1250 1/cm



Fraction of Pixels where Diff is within +/− 0.2 K	0.91572
Fraction of Pixels where Diff is within +/− 0.5 K	0.99942
Fraction of Pixels where Diff is within +/− 1.0 K	1

20 PCs - 99.9 % <±0.5 K

1250 1/cm



Fraction of Pixels where Diff is within +/− 0.2 K	0.93086
Fraction of Pixels where Diff is within +/− 0.5 K	0.99942
Fraction of Pixels where Diff is within +/− 1.0 K	1

150 PCs - 99.9 % <±0.5 K

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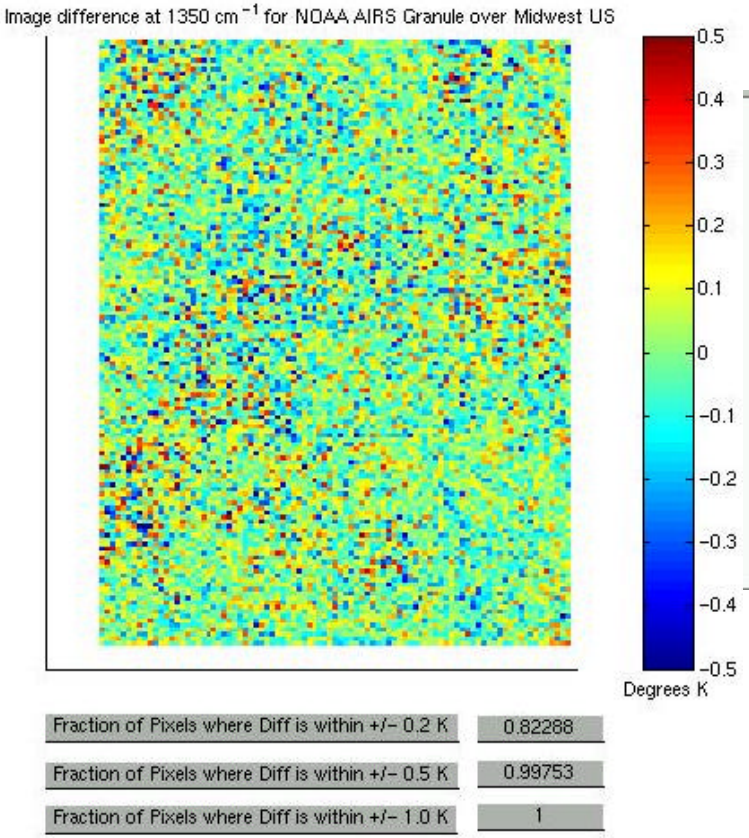
Hyperspectral Data Processing -

Why can we Compress Data Effectively ->

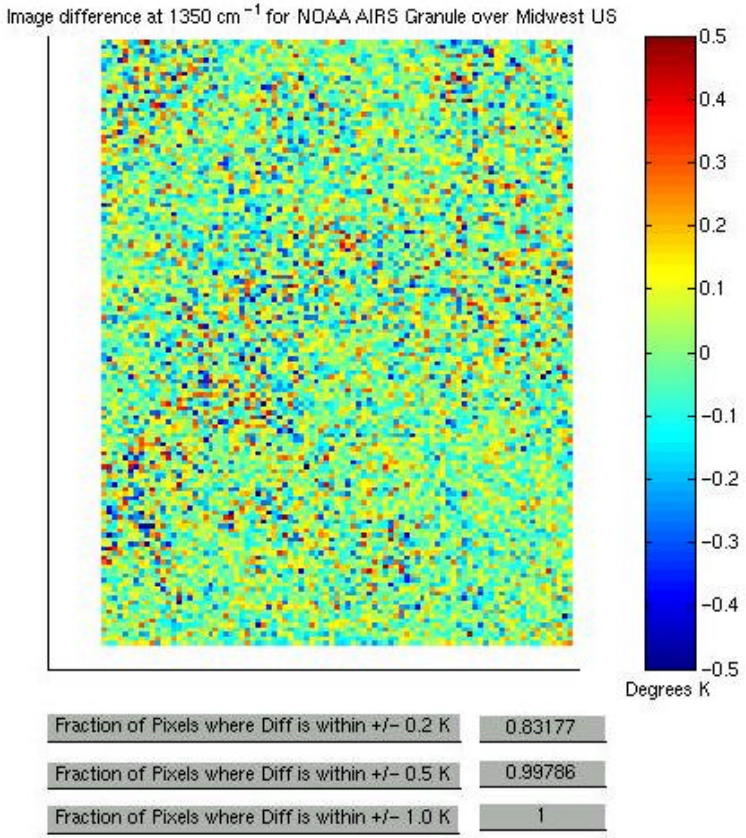
Signal+Noise Can Be Manipulated

1350 1/cm



20 PCs - 99.7 % <±0.5 K

1350 1/cm



150 PCs - 99.8 % <±0.5 K

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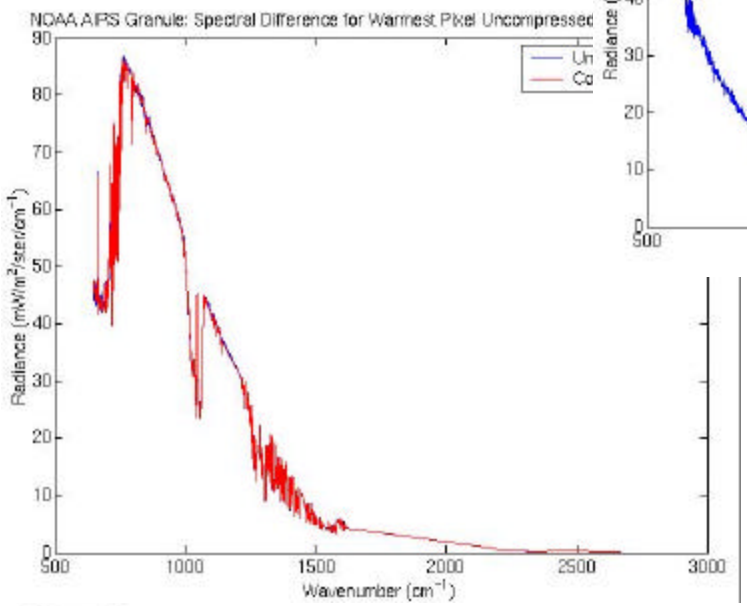
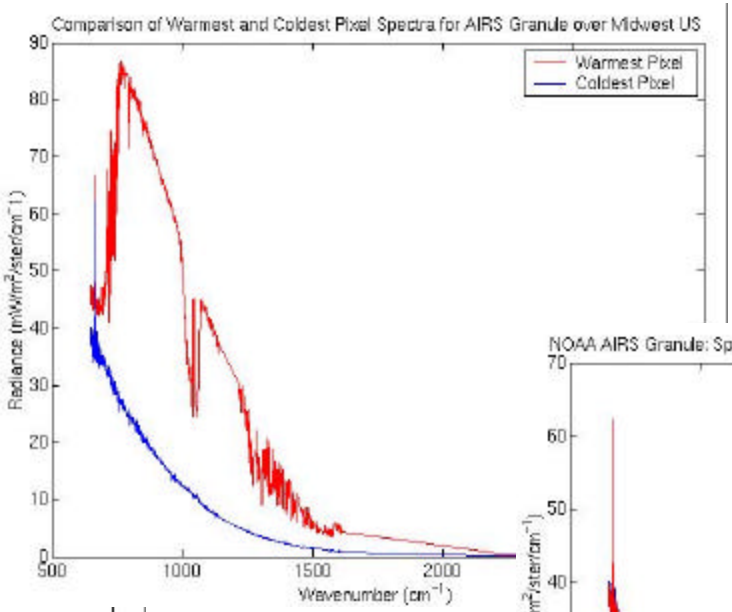
Hyperspectral Data Processing -

Why can we Compress Data Effectively ->

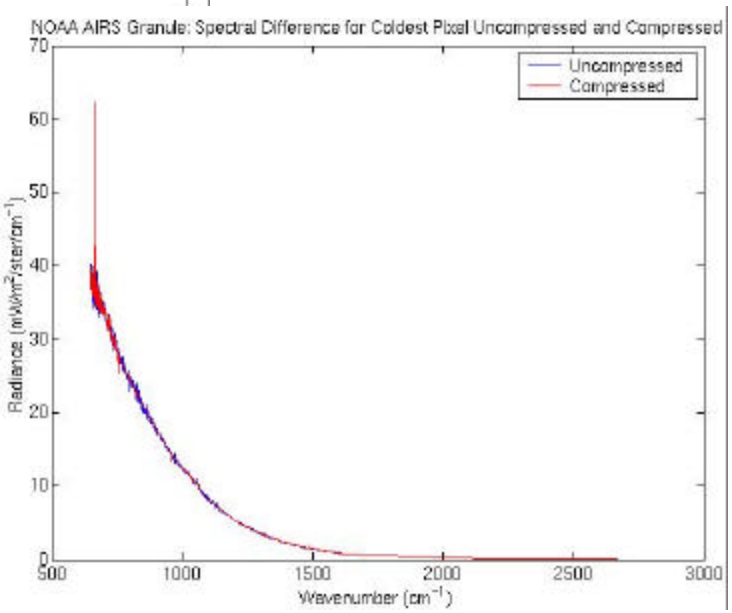
Compression Residual is Small

Warm Scene





Cold Scene



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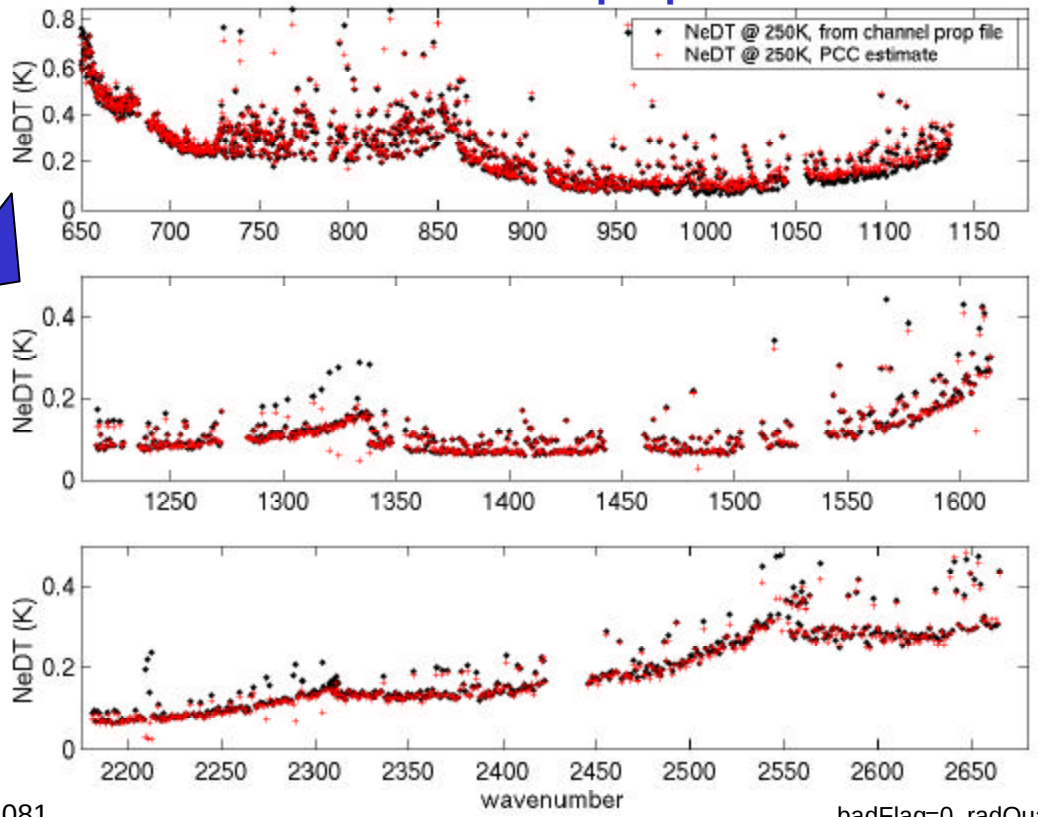
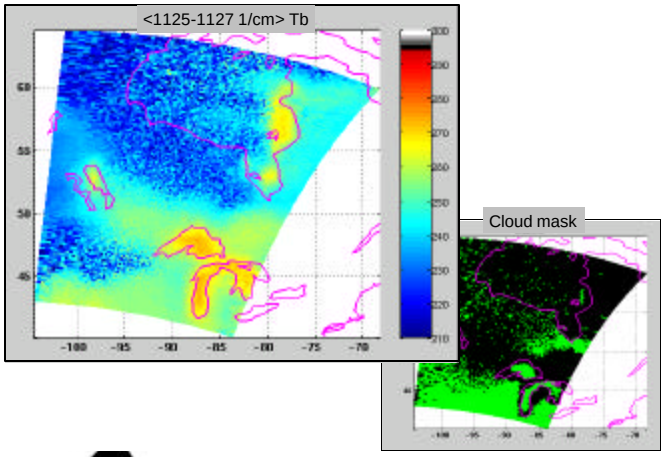
Hyperspectral Data Processing -
Why can we Estimate Noise Effectively ->
Noise are Well Estimated

Noise estimated well represent actual measurement noise

NeDT@250K: estimated from granule 081 and values from channel properties file



15-Dec-2000 granule 081



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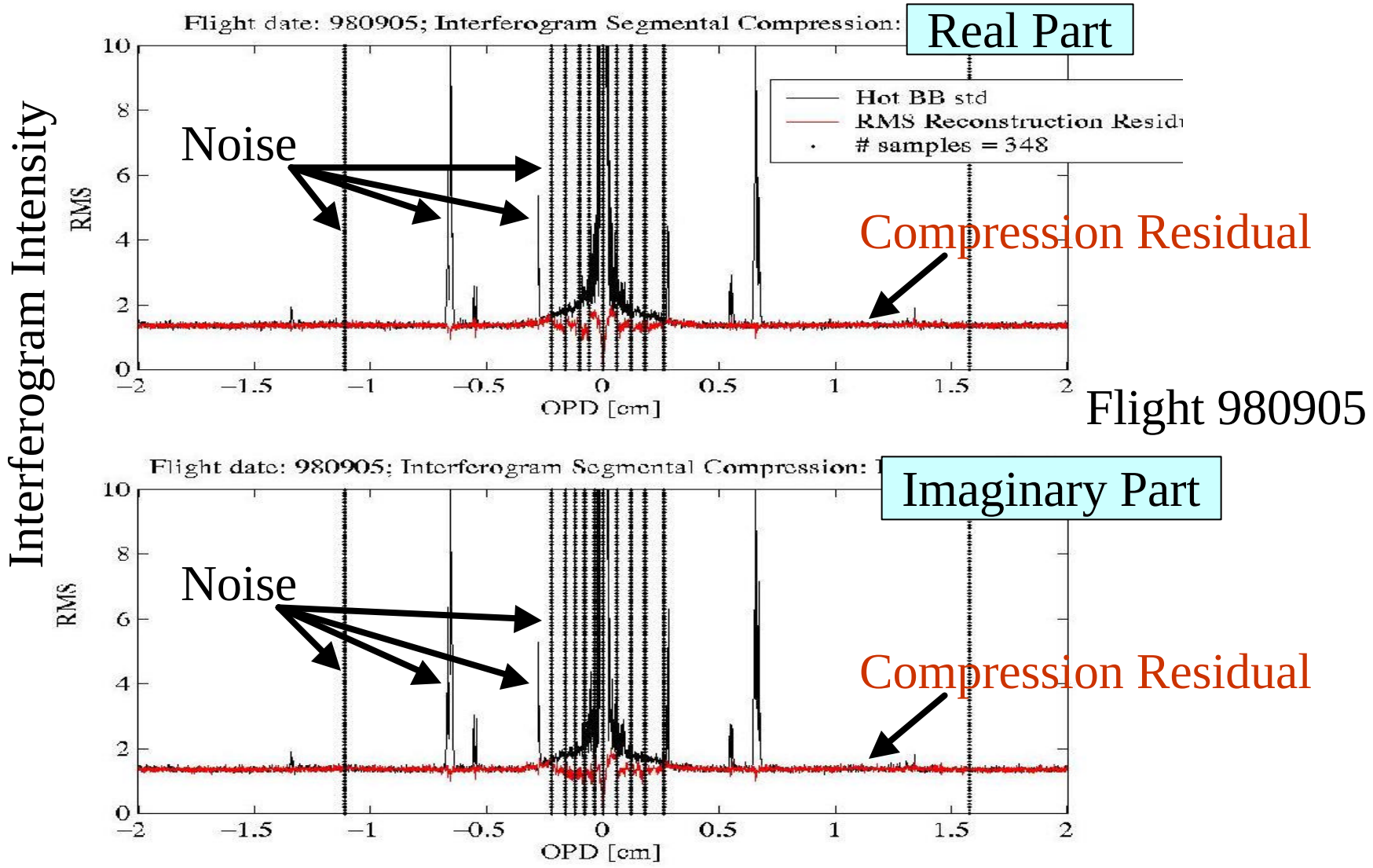
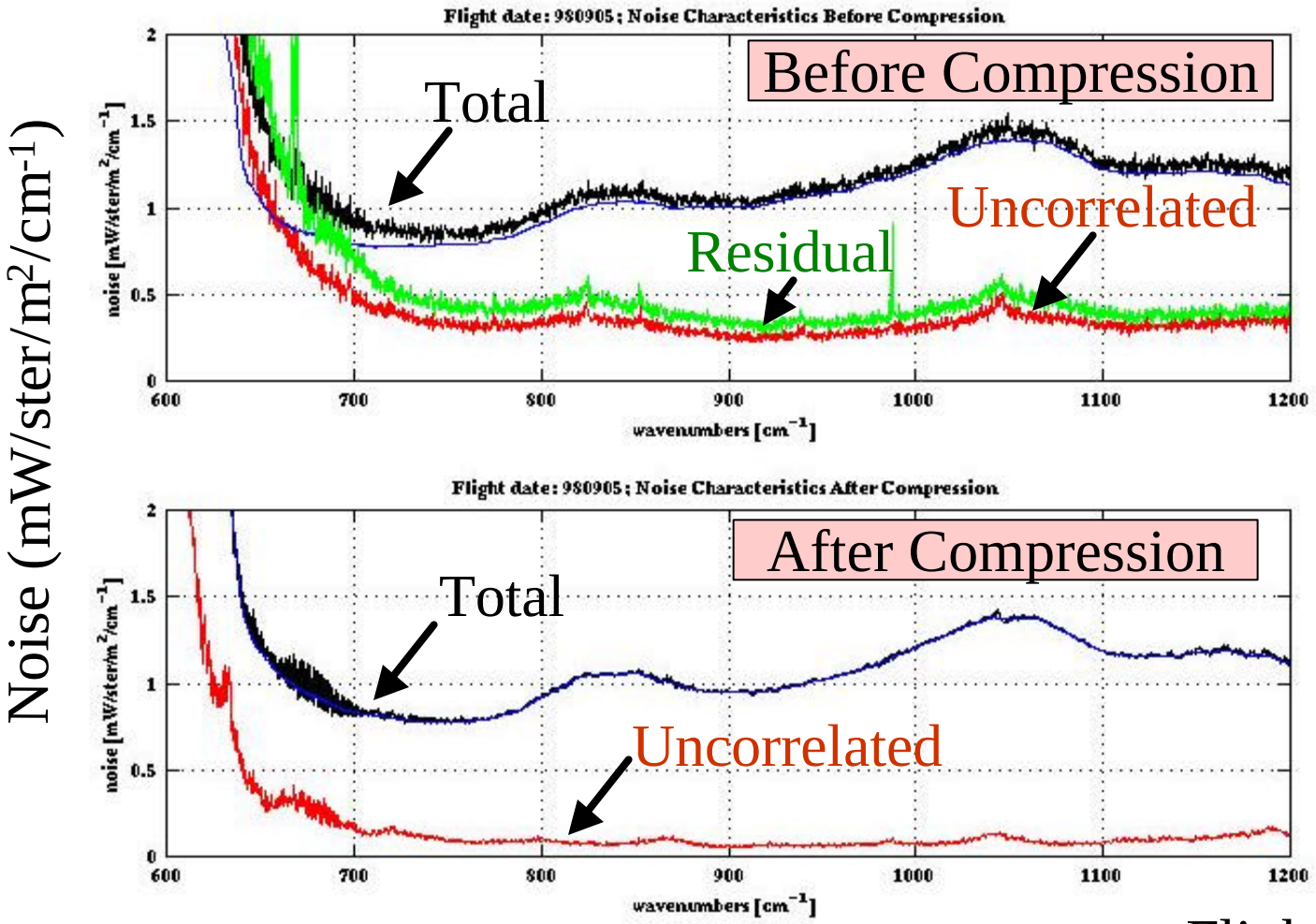
NAST-I Data Compression Procedure

- **Compression (Uncalibrated Interferogram Segmental)**
  - Selection of the length of the segments (11)
  - Derivation of the PCs from three NAST-I flights
  - Uncalibrated IFGs compression demonstration of a single flight (both real and imaginary parts, earth & black body views)
- **Calibration (uncompressed and compressed)**
  - Perform calibration of both original & compressed IFGs (using original and compressed black body, respectively)
- **Evaluation/Comparison**
  - Evaluation of the noise components (total, correlated, uncorrelated) for the original spectra
  - Evaluation of the noise components (total, correlated, uncorrelated) for the compressed spectra
  - Comparisons of noise before and after compression
  - Comparisons of compression residual with noise

NAST-I Data Compression Study
- Uncalibrated Interferogram



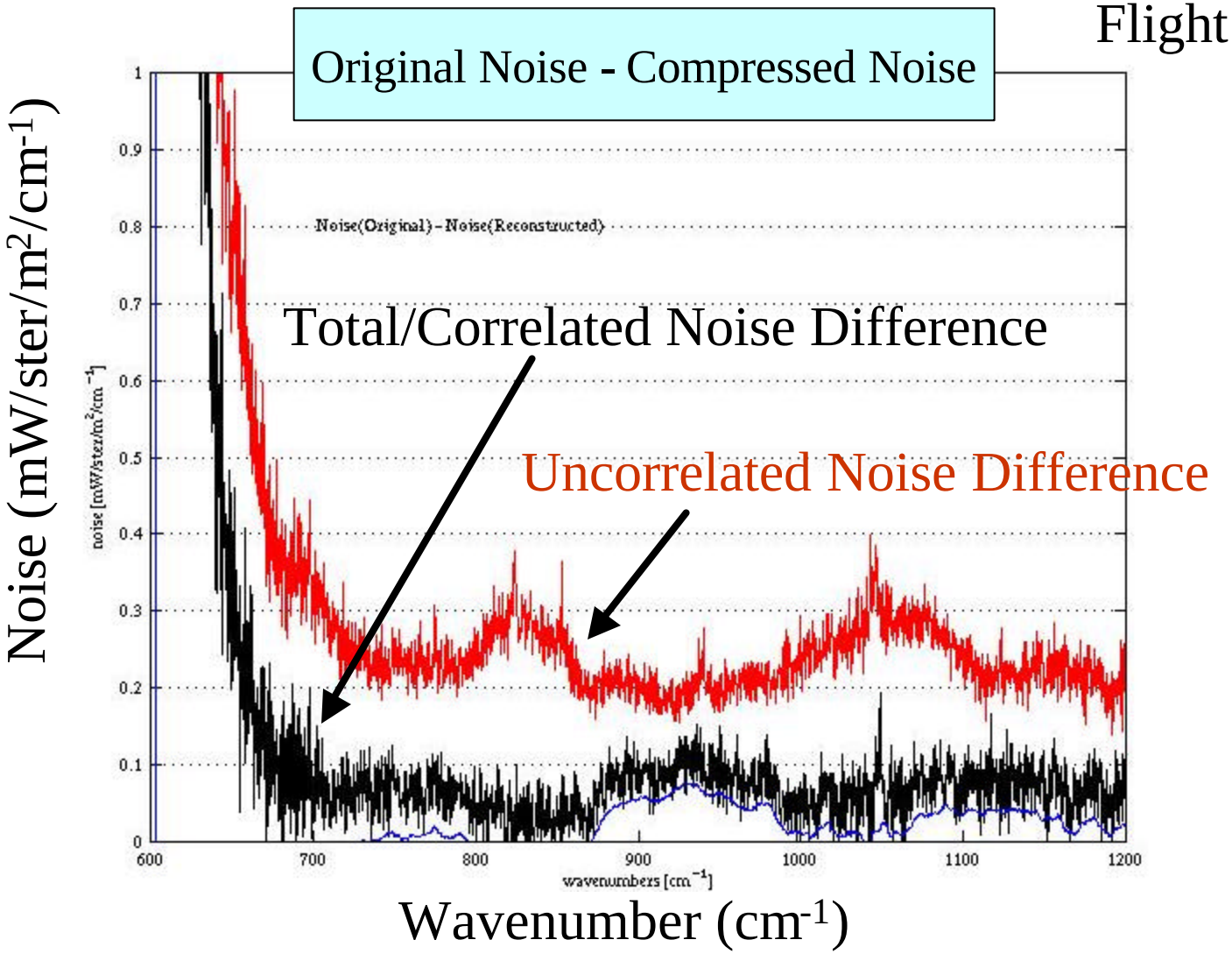
NAST-I Data Compression Study - Calibrated Spectrum



Noise (mW/ster/m^2/cm^{-1})

Wavenumber (cm^{-1})

Flight 980905

NAST-I Data Compression Study
- Noise Reduction Demonstration

Flight 980905